(NASA-CR-199078) REDUCING THE COMPLEXITY OF NASA'S SPACE COMMUNICATIONS INFRASTRUCTURE Annual Report, 15 Jul. 1994 - 14 Jul. 1995 (Maryland Univ.) 21 p

N96-15970

Unclas

G3/32 0061022

Annual Report

for

NASA Grant NAG 5 - 2648

Reducing the Complexity of NASA's Space Co nications Infrastructure

For Period: July15, 1994 - July 14, 1995

Introduction:

This report describes the activities and progress made during the first year under this grant by efforts at the University of Maryland, plus efforts by the subcontractors at Omitron, Information Sciences Incorporated, and Interactive Archives. Much of our effort has been directed at team participation, and collaboration, with the NASA Cost-Less Team for Mission Operations.

After the grant was initiated in July 1994, subcontracts were written with Omitron and Information Sciences Incorporated (ISI) on August 3, 1994. A supplement to the grant for extra work to be performed by ISI was added in February 1995. Additionally, another supplement was added in February 1995 to subcontract Interactive Archives in an expansion of the scope of the grant aimed at building a software toolkit for experimenting with a model of the end-to-end representation of space missions operations that we were formulating. Each of these efforts is being funded incrementally as funds become available for the grant from NASA.

During early Fall 1994 we participated in numerous meetings of the cost-less team to hear presentations of mission operations activities at the various NASA centers as well as some DOD activities. We then participated in planning the activities of the cost-less team for the remainder of 1994 and 1995. The activities to be pursued by the team, with participation of members on the grant, included: (1) the development of a common vocabulary (work on this had actually started at a workshop held in Spring 1994 at which some of the grant members participated); (2) a modeling, analysis and demonstration activity for developing the technical approaches to be used in specifying and designing mission operations on an end-to-end basis; (3) an operations concepts development activity to provide a way for operations concepts to more effectively drive mission operations architectures; (4) a workshop planning activity to put together a workshop on "sacred-cows" for Spring 1995; and (5) a collaboration activity to identify target missions on which to test our approaches.

Since early 1995 we have participated in these activities, and led some of them. We have participated in weekly teleconferences, met often with the team, and developed some of the technical material individually. Although many activities have been done jointly, the following sections provide a brief summary from the separate groups at: the University of Maryland, Omitron, ISI, and Interactive Archives. Due to the team nature of research on the grant appreciable overlap between the various sections can be seen. Since the sections each provide a perspective from a somewhat different point of view, and in several different forms, many different aspects of the work and accomplishments are depicted.

Several addenda are attached to this report, namely:

1. The paper: "Reducing the Cost and Complexity of Mission Operations Through a Reusable Object Methodology"

2. The draft paper: "Hierarchical Structuring of Petri Nets for System Modeling and Analysis"

3. ISI final report for subcontract Z623801.

Section Prepared at the University of Maryland:

The participants at the University of Maryland are Raymond E. Miller, Principal Investigator.for the grant, plus two graduate students; Hong Liu and Junehwa Song. Miller and Liu have been involved with the grant since its inception, and Song was active on the grant from February through May 1995. In addition to our team activities outlined in the introduction, Miller put together the first few initial drafts of a paper "Reducing the Cost and Complexity of Mission Operations Through a Reusable Object Methodology' which was originally intended to be a book chapter. The final version of this document (Draft 15) is appended to this report. It involved the efforts of many of the team members as indicated by the list of authors. This document provides a very good overview of some of the modeling and analysis work that we have accomplished, as well as a discussion of the object oriented approach (reusable object technology) that we are developing. The Petri net analysis that we discuss is further developed technically in another appended draft paper "Hierarchical Structuring of Petri Nets for System Modeling and Analysis" by Miller and Liu. This paper provides the basis for us to be able to do a high level flow analysis for logical correctness, then later do hierarchical refinement of the model, getting closer and closer to an implementation, without having to do the extremely difficult task of flow analysis at the detailed level. Implementation in an object oriented manner, with reusable components then follows in a natural way. That is, the Petri net model for flows, and the object oriented approach for ease and cost savings, appear to complement each other nicely for a design methodology. We intend to continue the development of this approach during the coming year, and to try to see how it works for a real mission development.

In other activities Miller and Liu attended the Space Workshop'95 in Denver, Colorado on March 6-11, 1995. Miller met with the team at JPL on April 19-21, 1995, and Miller, Liu and Song participated in the NASA Cost-Less Workshop on Sacred-Cows at Wallops Island Facility on May 22-26, 1995. At this workshop Miller served as Facilitator for the group working on automation related cows, with Liu assisting. Junehwa Song, working closely with Don Hei of Goddard, put together the structure for the publication of the workshop results on the World-Wide-Web of Internet and publicized these activities even as the workshop was progressing.

The plans for the book chapter document noted earlier have changed since the initial conception. Rather than appearing as a book chapter, a modified version (which is currently being worked on) will be presented as a paper

at a conference in Logan Utah this September. Also in progress is the installation of some computing equipment, obtained from NASA under the grant, at the University of Maryland to provide more effective electronic communication and collaboration with the team, including the software development of the toolkit. We expect that this laboratory will be operational on our network by the end of the summer.

Section Prepared by Omitron, Incorporated:

Annual Technical Report
for
Reducing Complexity of NASA's Space Communications Infrastructure

For Period
July 15, 1994 through July 14, 1995

Prepared for
Professor Raymond E. Miller
Department of Computer Science
A. V. Williams Building
University of Maryland
College Park, MD 20742

Prepared by
Omitron, Incorporated
6411 Ivy Lane, Suite 600
Greenbelt, MD 20770

Overview

This report describes the range of activities performed during the annual reporting period in support of the National Aeronautics and Space Administration's (NASA) Code O Success Team - Lifecycle Effectiveness for Strategic Success (COST LESS) team. This team evolved from the Blue Team for Space Communications, which was put in place in FY92, through the Code O Success Team (COST) to become the COST LESS team in FY94. The overall goal of the COST LESS team is to redefine success in a constrained fiscal environment and reduce the cost of success for end-to-end mission operations. This goal is more encompassing than our original proposal made to NASA for reducing complexity of NASA's Space Communications Infrastructure and this is reflected in the range of activities described in this report.

The COST LESS team approach for reengineering the space operations infrastructure has a focus on reversing the trend of engineering special solutions for similar problems. To support this approach, the team effort needs to be multi-dimensional and multi-disciplinary. In preparing their master plan beginning in FY95, the team identified six major activities to achieve example results in three areas. These activities were:

1. Mission Operations Common Vocabulary
2. Modeling, Analyses and Demonstrations
3. Operations Concepts Methodology
4. Sacred Cows Workshop
5. Extreme Ultra-Violet Explorer (EUVE) Pilot Experiments
6. Sounding Board and Interchanges.

The example results included:

1. Common vocabulary
2. Re-usable solutions to simplify engineering and operations
3. Operations concepts to maximum value.

This report identifies the work performed to support these six activities. Considerable effort was expended in participation in a range of working sessions and meetings, which were essential to meet the requirements for the work performed. The details of these working sessions and meetings is included. In addition, work performed or in progress for preparation of documentation and papers, which highlight the activities supported is provided. Finally a conclusion summarizing the status at the end of the reporting period and plans for the following period is provided.

Activities

The work performed in support of the six activities was a consolidated effort by the University of Maryland (U of MD) group in support of the COST LESS team. The U of MD group was managed by Professor Raymond Miller of the Computer Science Department and supported by Omitron, Inc. of Greenbelt, Maryland, and Information Sciences, Inc., of Denver, Colorado. Later in the reporting period, support from Interactive Archives, Inc., of Greenbelt, Maryland, was added. The work performed by Omitron which is described in this report, was therefore a part of the overall group effort.

Mission Operations Common Vocabulary

This activity was managed by Mr. Al Ellman of the Jet Propulsion Laboratory (JPL). The activity used as input several lexicons available from the various NASA field centers in addition to the range of tasks which were defined in the mission operations area from work performed at the First NASA Workshop on Mission Operations, which was held at the Wallops Flight Facility, Wallops Island, Virginia in 1994. Work performed by Omitron

was primarily in identification of inputs, earlier support at Wallops in defining the range of tasks, and in review of the material prepared.

Modeling, Analysis, and Demonstrations

This activity was managed by Professor Raymond Miller. Emphasis was placed on developing a Reusable Object Methodology as a potential candidate for reducing the cost and complexity of systems for supporting mission operations. This methodology was an outgrowth of a system developed by Dr. Frank LoPinto of Interactive Archives for the National Space Science Data Center (NSSDC) at the NASA Goddard Space Flight Center (GSFC). The methodology was developed and published in the form of a draft chapter for inclusion in a book on Cost Effective Space Mission Operations edited by Daryl Boden and Wiley Larson of the United States Air Force (USAF) Academy. The chapter was prepared by numerous authors and Omitron participated in the preparation of several sections and in the review of the overall manuscript.

Operations Concepts Methodology

This activity was managed by Dr. John Willoughby of ISI. Two mini-workshops were held at Omitron in support of developing the operations concepts methodology. Omitron played an active role in this activity in developing a cube model to represent an operations concept, and in refining the categories and distance measures used in a distance model, which was based on earlier work by Rhoda Hornstein of NASA Headquarters (NASA HQ) and John Willoughby. In refining the distance model, various operations concepts documents for future and current NASA missions were evaluated and an Operations Cost Model for Flight Projects obtained form the JPL Project Design Center was reviewed and incorporated as appropriate.

Sacred Cows Workshop

This Second NASA Workshop on Mission Operations was hosted by the COST LESS team and sponsored by the Associate Administrator for Space Communications. It was held May 22-26, 1995 at the Wallops Flight Facility. Considerable effort was expended by all members of the COST LESS team in the preparation and conduct of the workshop. Omitron was actively involved and in particular facilitated one of the six sub-groups which evaluated sacred cows in the operations area.

EUVE pilot experiments

This activity was managed by Dr. Don Hei, of the GSFC. Work performed was limited to evaluation of proposals submitted for reducing the cost of EUVE mission operations for an extended mission.

Sounding Board and Interchanges

Support in this area was on an ad hoc basis to respond to queries and to provide an exchange of information between outside organizations and the COST LESS team.

Working Sessions

A range of working sessions was supported with particular emphasis on supporting the six major activities.

Information Gathering Presentations

Approximately forty presentations by NASA project managers, technical managers, scientists, and industry specialists was arranged and/or attended for the purpose of assimilating information and obtaining the insight of experienced professionals in the space operations arena. Several of the speakers were proposed by and/or arranged by Omitron

personnel. These presentations were consolidated over several weeks early in the reporting period and provided a valuable baseline for the work performed.

Operations Concepts Mini-Workshops

Two in-depth mini-workshops attended by NASA HQ and field center personnel and industry representatives were held at Omitron to develop the operations concepts methodology for activity 3.

AIAA Workshop on Reducing the Cost of Space Operations

This workshop was organized into several parallel working sessions in three main areas:

A. Management and Organizations Issues
B. Space Program Development Operations Issues
C. Technology Issues

Session B3 on Mission Operations Control Architecture and Implementation was attended by Omitron personnel. Other attendees at this session included Wiley Larson of USAF and Gael Squibb of JPL.

FRED

The NASA Administrator, Mr. Daniel Goldin, gave an address to the participants at the Second NASA Workshop on Mission Operations at the Wallops Flight Center. In this address, Mr. Goldin charged the workshop with helping to identify the way in which NASA could achieve considerable savings in the space operations infrastructure. In responding to this charge, the agenda for the workshop was reviewed and several sacred cows added of relevance to Mr. Goldin's direction. In addition, in evaluating follow-on activities at the close of the workshop, it was determined that considerable effort was needed to provide necessary guidance by late July for consideration by the Administrator.

A three week working session was therefore conducted during June 1995, to define a new way of doing business for NASA. In this session, the Fundamentals and Reusables for new Economic Directions (FRED - strategic) or Find Redundancy - Eliminate Duplication (FRED - tactical), was defined. This concept was made available on the World Wide Web (WWW) for general review and is currently being updated for presentation to the Administrator.

Meetings

Several meetings and symposia were attended for information gathering and dissemination. These included:

Space Ops 94, Third International Symposium on Space Mission Operations and Ground Data Systems, November 15 - 18, 1994, Greenbelt, MD

GSFC Small Spacecraft Workshop, February 8, 1995, Greenbelt, MD

Space Workshop 95, March 8 - 10, 1995, Denver, CO This included a working session at ISI.

Working meeting at JPL, Pasadena, CA, April 18 - 20, 1995. This included presentations on New Millennium, Services Fulfillment Reengineering, Mars Pathfinder Development Approach, Low Cost Mission Operations Control Architecture (LoCoMOCA) and the JPL Flight System Testbed

Papers

Documentation of the analysis and work performed has been published or is in preparation in the form of a book chapter and technical papers. These include:

Reducing the Cost and Complexity of Mission Operations Through a Reusable Object Methodology, Izellar E. Cureton-Snead et. al., for publication in the book entitled Cost Effective Space Mission Operations, edited by Daryl Boden and Wiley Larson, USAF Academy.

Introducing a Methodology for Describing Operations Concepts and Assessing their Value, R. S. Hornstein et. al., to be presented at the 1st International Symposium on "Reducing the Cost of Spacecraft Ground Systems and Operations", Rutherford Appleton Laboratory, Oxfordshire, England, September 27 - 29, 1995.

On-Board Autonomous Systems: Cost Remedy for Small Satellites or Sacred Cow?, R. S. Hornstein et. al., 46th Congress of the International Astronautical Federation, Oslo, Norway, October 5, 1995.

Conclusion

The work performed in support of the COST LESS team to date has the potential to significantly affect the NASA Space Operations infrastructure. Work in the major activities will continue to this end in the next reporting period. Activity 4, Sacred Cows Workshop is completed. However, the COST LESS team plans to hold a major workshop each year and tentative planning for 1996 is underway. Current emphasis at the end of the reporting period is in final preparation of publications and in refining the FRED concept. If this concept obtains general acceptance, significant effort will be involved in maturing the concept for implementation.

Section Prepared by Information Sciences Incorporated:

1.0 INTRODUCTION

Information Sciences, Inc. (ISI) has been a subcontractor to the University of Maryland in the performance of certain tasks described in the Statement of Work. This report is being submitted in partial fulfillment of the reporting requirements as shown in item number 6 of the contract document.

2.0 SYNOPSIS OF WORK PERFORMED

ISI's efforts for the reporting period included a range of activities which were coordinated with NASA advisors via weekly telecons. These activities included participation in the COSTLESS Team, a cross cutting group investigating NASA procedures and policies looking for elements of cost savings in NASA Mission Operations. Six tasks were defined by the Team for completion during the 1994-95 fiscal year. ISI was assigned responsibility for Activity Three entitled Operations Concepts Methodology. The majority of the effort described in Section 3.2 of this report is in conjunction with the performance of this task. The Operations Concept workshops and the paper presenting the results consumed a major part of the work accomplished during this period. Additional support to the Team involved review of numerous NASA/Contractor publications, attendance at NASA center briefings, attendance at national and international conferences, conducting workshops on key cost saving strategies, and writing technical papers for conference presentation. Where required, ISI also supported COSTLESS presentations to the NASA Administrator, supported COSTLESS sponsored work sessions in Greenbelt, MD, Denver, CO, and Pasadena, CA. ISI further supported the COSTLESS team via review, advice, and evaluation of numerous briefings, and the draft of a chapter on cost savings being published by the US Air Force Academy. Finally, ISI performed the specific tasks as shown in Section 3.0 of this report.

3.0 STATEMENT OF WORK AND TASKS PERFORMED

This section delineates each item in the Statement of Work. Following each item is a description of each task performed to fulfill that item.

3.1 PERFORM A FUNCTIONAL DECOMPOSITION OF THE INFORMATION HANDLING AND RESOURCES MANAGEMENT AND CONTROL AREAS

Perform a functional decomposition of the Information Handling and Resources Management and Control areas ensuring that all elements are considered to characterize the problem domain for each area. The decomposition will be performed initially to a high level of abstraction, but will be taken to lower levels necessary to completely define sub-functional areas necessary for supporting the Code O role. This decomposition will attempt to capture all sub-functions for the range of projects in the NASA mission model, but will not be focused on individual project requirements.

The first task performed under the subcontract called for a decomposition of the NASA Mission Operations area, growing out of the first COSTLESS workshop held at Wallops Island in May, 1994. The initial work in this area resulted in the two categories of Information Handling and Resources Management and Control being defined as the top level categories of mission operations.

3.1.1 ANALYSIS OF TECHNICAL DOCUMENTATION FURNISHED BY NASA CENTERS

Over a three month period, the COSTLESS team received as series of briefings and presentations from most of the NASA Centers, describing their approaches to Mission Operations. These presentations provided input into the development of the Functional Decomposition.

3.1.2 DEVELOPMENT OF FUNCTIONAL DECOMPOSITION

The first draft of a Functional Decomposition was recently completed and is included in Appendix A. It depicts a hierarchic breakdown of the two areas. Additional functional breakdown activity occurred under efforts supported by the University of Maryland and Omitron Inc. ISI supported these activities as a participant in many working meetings but was not the lead on this task.

3.2 PERFORM AN ANALYSIS TO DEVELOP CONCEPTS AND ARCHITECTURES

Perform an analysis to develop concepts and architectures which satisfy the functional areas obtained from this decomposition, where these concepts are architectures utilize functions which are incrementally realizable from the sub-functions obtained from the decomposition. In preparing these concepts and architectures innovative approaches need to be developed which have a strong emphasis on use of COTS systems and services. This analysis is multi-disciplinary and will draw on expertise in fields such as computer science, operations research, systems engineering, space sciences, and communications. Recognition of standard functions where they are appropriate is important. It is also essential that concepts and architectures considered are not bound by current systems approaches and functional distributions. Realization of significant reductions in complexity while maintaining successful support for the Code O role are likely to evolve new and interesting solutions.

Additional Activities for University of Maryland - December 9, 1994
Additional tasks to be performed shall be:

a. *Conduct an analysis and development activity involving participants from various NASA centers, aerospace companies, the U.S. Air Force and academic institutions which has the goals of 1) developing a framework for describing space mission operations concepts that can capture a broad range of concept possibilities and that facilitates explicit comparisons among alternatives, and 2) developing a mechanism for predicting the impact on life cycle cost and effectiveness from selecting among operations concept alternatives described.*

b. *Coordinate the operations concept activity (above) with parallel activities performed by the University and others, which seek to define a common vocabulary and a set of functional elements that describe end-to-end space mission operations.*

The second task performed under the subcontract called for the formation of a methodology which would enable NASA to create and evaluate concepts for Mission Operations early enough in the life cycle of a mission to determine feasibilities of operational scenarios as well as cost and technology drivers.

3.2.1 Develop Syllabus for Workshop Series on Operations Concepts

The first step in executing the task was to conduct a series of Workshops with project managers, system designers and program evaluators to examine the current methods for developing operations concepts and to devise new methods to improve the process. Two workshops were planned, and a third workshop was added later. The agenda for the three workshops in shown in Appendix B.

3.2.2 Conduct Series of Workshops Investigating Concepts

The first two workshops were held in January and March, 1995, each lasting for two days. A third workshop was held in April. The fourth workshop is scheduled for July, and will be referred to briefly in this report. The workshops followed an agenda designed to investigate the elements of a mission that could be stated in the form of a measurable operations concept, with the aspects of the concept stated as a spectra of operational options. Those operational options were then applied to a fictitious mission (PSECC) as well as upcoming missions NASA was already anticipating. The results of the workshops are highlighted in subsequent tasks. A subset of the materials used in each workshop is contained in Appendix C.

Identification of technology including tools and toolsets which support implementation and evaluation of these concepts and architectures.

Assembly and synthesis of applications using these concepts and architectures which can be evaluated against metrics to verify satisfying the NASA Charter of *"better, faster, cheaper"*.

3.2.3 Prepare Minutes and Summarize the Findings from Each Workshop

Following each workshop, the information gathered from the participants was synthesized and distributed to attendees. The synthesis of the first three workshops is shown in Appendix D.

3.2.4. Prepare and Deliver Paper on Findings from Workshops

An abstract describing this task was submitted to the International Symposium "Reducing the Cost of Spacecraft Ground Systems and Operations" to be held September 27-29, 1995. The abstract appears as Appendix E.

3.2.5 Assist in Composing & Evaluating Material for a Book to be Published About Mission Operations

In support of the book chapter entitled "Reducing the Cost of Mission Operations Through a Reusable Object Methodology", several drafts of material directed at defining operations concepts was submitted to the authors. Several drafts of the subsequent chapter were reviewed and revised.

3.3 Identify Tools and Toolsets which Support Evaluation of the Concepts

Identification of technology including tools and toolsets which support implementation and evaluation of these concepts and architectures.

The presentations mentioned in Section 3.1.1, the information gathered in the workshops described in Section 3.2, and two site visits to the Jet Propulsion Laboratory are providing input into the performance of this task. The criteria for evaluation is in preparation.

3.3.1 Conduct Review of Existing and Planned Tools to be used by NASA Centers to Support the Concepts of FASTER/BETTER/CHEAPER

During the site visits to JPL a series of presentations about the New Millennium program of smaller, cheaper spacecraft was attended, as was a symposium focusing on the similarities among NASA's approaches to managing these new missions.

3.3.2 Prepare and Deliver Paper Describing Tools for Supporting Common Planning and Scheduling Architectures

Following the review described in Section 3.3.1, an abstract and paper was subsequently written emphasizing the area of Planning and Scheduling. That paper is contained in Appendix F.

3.4 ASSEMBLE APPLICATIONS USING THESE TOOLS

Assembly and synthesis of applications using these concepts and architectures which can be evaluated against metrics to verify satisfying the NASA Charter of "better, faster, cheaper".

No work has been performed on this task during this reporting period.

3.5 IDENTIFY METRICS PERMITTING EVALUATION OF CONCEPTS

Identification of metrics which allow evaluation of reduced complexity and cost improvements of the concepts and architectures to determine optimal approaches or solutions.

The Functional Decomposition described in Section 3.1 is in its first draft , is being refined by other grant participants, and is expected to undergo even further analysis and definition as a result of the workshops described in Section 3.2.3. The top level elements of Information Handling and Resources Management and Control are now part of a larger conceptualization of NASA Mission Operations. The metrics developed for the workshops were broader in scope and intended to evaluate operations concepts in a larger context.

The second workshop on Operations Concepts began the task of defining an appropriate set of metrics using cost, schedule and performance as the criteria for evaluation. The preliminary results of this work is shown in Appendix G.

This concludes the summary of work performed under Subcontract Number Z623801, as of July, 1995.

Section Prepared by Interactive Archives, Incorporated:

Interactive Archives, Inc. has been pleased to participate in the activities in support of the NASA Cost Less objectives. We have focused on the following two areas:

1. Architecture for COTS Interoperability,

2. Inter-object communication mechanisms.

This report explains each of these ongoing efforts and what has been achieved this year. We conclude with a statement of our current goals.

Area 1: ARCHITECTURE FOR COTS INTEROPERABILITY

The goal of this activity is to demonstrate how to incorporate existing components into new systems without modifying the existing components. In many cases we may not be able to modify the components because, for example, we do not have access to the source code. All we do is arrange for the COTS (commercial off the shelf) system to receive inputs (in a generally non-standardized format). We must then access, or intercept, the output of the COTS system and analyze the results so that they can be represented in the terms required of the new system. The situation is often the same for GOTS (government off the shelf). Even though the source code is (theoretically) available, it may be written in an unfamiliar and/or archaic language. More often, the amount of software and the level of documentation makes understanding the code a practical impossibility. (Interestingly, software as well as automobiles can be "totaled" - i.e., when it costs less to replace than to repair or maintain.)

We have pursued this investigation by developing a prototype using the Transportable Payload Operations Control Center (TPOCC) system developed at Goddard, and the Mosaic World Wide Web browser developed at the University of Illinois. TPOCC is a large and complicated system for controlling spacecraft payload. Mosaic is a graphical application that was designed to read documents formatted in the Hypertext Markup Language (HTML). We developed a set of reusable objects to interface with TPOCC and Mosaic. These objects are implemented as asynchronously executing, networked Unix processes. One object interfaced with Mosaic. Two others interfaced with TPOCC. Neither Mosaic nor TPOCC was modified. The interfacing objects were placed into a hierarchy with other objects. These formed a layered architecture consisting of COTS/GOTS

components and our own components. The effect was a seamless system in which users interfaced TPOCC via Mosaic. The system was demonstrated at a Space Operations workshop in Denver, at a meeting at JPL, and to interested individuals at the Cost Less Sacred Cows Workshop at Wallops Island. The system and the Cost Less project were presented to a panel of the Consultative Committee on Space Data Systems (CCSDS) at an International Workshop in Toulouse, France.

Area 2: INTER-OBJECT COMMUNICATION MECHANISM

According to Reusable Object Technology, the set of principles we use to develop distributed systems, the communication among objects must be simple and easy to understand. The overriding goal is to compartmentalize complexity within the objects in order to achieve simplicity in their interactions. Our method of representing the interactions is through an "object communication model" and graphical representations of the model.

This goal is challenged by the realities of mission operations. First, the complexity of operations, though not a severe as it initially appears, requires a large number of simple reusable objects (as apposed to a small number of complex, non-reusable ones.) This implies multiple layers of objects which requires an efficient method of categorizing and routing messages. Second, there may be cases where objects will have to maintain "out of band", high rate communications channels that cut across (object) organization boundaries. Our challenge is to provide efficient support for such bulk transfer channels while maintaining the simplicity and tractability of our existing communication models.

We have made progress on the first of these challenges. Specifically, as the Mosaic Forms used to communicate with our objects became more complicated, we needed a simpler way to unpack and process the information in the Forms. Even more specifically, we needed to reduce the number of lines of new code that must be developed for each new Form (or more generally input message format.) Our approach was to develop a prototype where input forms are translated into Standard Formatted Data Units (SFDUs) which are information packaging structures and procedures recommended by CCSDS and by ISO. By decomposing input messages into well understood "blocks" (think about blocks of fields of government forms) we can reuse "block processing" software and develop new code only for new blocks. Prior to this we had to develop new software for each new message format even if the new messages differed only slightly from the older ones.

The SFDU-based "block processing" approach was prototyped and has resulted in simpler Mosaic interfacing objects. We plan to extend the approach to cover general object to object communications.

CURRENT GOALS AND ACTIVITIES

Our current activities are as follows:

1. Produce a technical paper entitled "The Principles of Reusable Object Technology". This will explain reusable object technology and provide guidlines for practitioners. It will also provide a conceptual basis for analyzing mission operations requirements in terms of intelligent agents.

2. Continue investigation of the SFDU-based object communication model. We will test this concept for a variety of object interactions to determine guidlines for how to define the "blocks" (which are called Label Value Objects in CCSDS parlance) and how to integrate outputs produced by the block processing methods. This will involve making recommendations to NASA and CCSDS regarding rules for describing organizations of objects.

3. Investigate archiving and retrieval techniques for handling reusable software objects of interest to mission operations.